



Florida Department of Transportation Research Modification of LRFD Resistance Factors Based on Site Variability BD545-76

Deep foundations (i.e. pile/drilled shaft) support many structures, such as bridges and elevated roadways. In Florida, designs for deep foundations have evolved from small diameters (e.g., 14" piles; 48" drilled shafts) in the 1980s to very large diameters (e.g., 66" piles; 108" drilled shafts) in recent years. Larger piles and/or shafts offer smaller pier-cap footprints, which reduces costs and right-of-way issues. However, new deep foundation systems have lower redundancy and a higher susceptibility to soil/rock variability, which may lead to a higher probability of collapse. This problem is compounded because, until 2003, sites were often tested at distances up to hundreds of feet from the final construction site. Also in recent years, the Florida Department of Transportation (FDOT) and many similar agencies have moved from stress-based Allowable Stress Design (ASD) to the reliability/strength-based Load and Resistance Factored Design (LRFD).

A key in LRFD is the resistance factor, Φ . Using their extensive database of load tests with adjacent borings and laboratory tests, FDOT set LRFD resistance factors for Florida, based on assumed reliability indexes and treating limestone as a uniform substrate. However, strength characteristics of Florida soil and rock are highly variable, and resistance factors are unlikely to be constant across any single construction site.

In this project, University of Florida researchers developed resistance factors that better reflect the properties of specific sites. Of special interest to the researchers was the correlation problem inherent in the soil/rock structures. This refers to the composition of soil and rock – and

their strength – which is randomly distributed. Therefore, averaging, which relies on randomness, does not correctly interpret soil/rock properties that will be the basis for structural designs. The researchers also examined the correlation of load testing and recommended resistance factors.

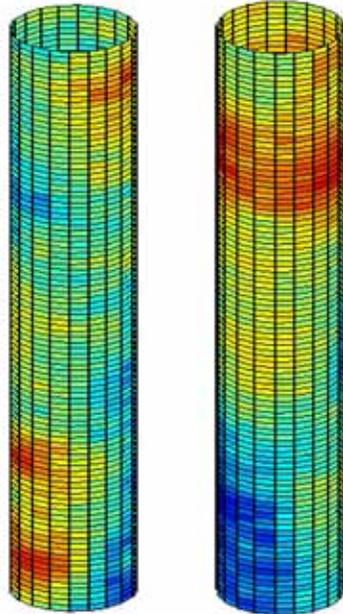
This has important implications for design, and one pier failure has resulted from the use of too high resistance factors.

In the first of five tasks, researchers examined data in the FDOT Geotechnical Internet-Based Database and selected a site for analysis. Test locations at the site relative to final construction allowed discrimination between spatial variability and design approach bias. In the second task, expected coefficients of variation for drilled shaft axial capacities were developed from shaft dimensions and rock strength variability and its correlation length.

Tasks three, four, and five focused on the development of resistance factors. In task three, factors were developed for the case where

limited borehole or laboratory testing data was available, for example, when data is based on sites located away from the final construction site. Task four developed resistance factors based on data taken within the construction footprint. Task five developed resistance factors for sites which included field load testing.

To aid designers in applying the approach developed in this project, the researchers included a number of examples. They also created a quadrant chart for use in shaft design of single and group pile/shaft layouts. The chart considers side and tip resistances and layered systems.



The nonrandom nature of rock strength is shown graphically in borehole data from nearby shafts.